THE DEVELOPMENT OF A PRACTICAL TECHNIQUE FOR ACHIEVING REALISTIC PHOTOGRAPHIC IMAGES OF SET INSECT SPECIMENS

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Abstract. The development of equipment and techniques for the photography of set insect specimens is described. Information is given to enable the equipment to be made easily, using readily available materials. A method has been developed which gives repeatable and consistent illumination of the specimen including controlled directionality of lighting. True representation of metallic and iridescent colours, pollination patterns, surface sculpture and texture is assured.

The equipment is inexpensive, compact, robust without being excessively heavy, and it breaks down into conveniently transportable modules. It is designed to be adaptable and easily tailored to suit current 35 mm camera systems. This design avoids the risk of flare in the resulting photographs and optimises specimen management including positioning, orientation and focusing.

Set specimens covering ranges of body lengths from 100 mm to 2 mm are routinely photographed and the equipment is capable of photographing small structural details as small as 0.3 mm long. This range of specimen size is accommodated using photographic Macro lenses, between 20 mm and 50 mm in focal length, in conjunction with extension tubes. A mixed batch of 36 insects of varying sizes can be typically photographed comfortably in less than two hours.

The use of consistently high quality standardised photographs via Photo CD or Internet access is discussed as an aid to specialists working on groups of insects in which specimens are widely scattered amongst a number of institutions; this technique would enhance the availability of visible characters for taxonomic and identification purposes.

INTRODUCTION

In 1995 I resumed an active interest in entomology and joined the Lancashire and Cheshire Entomological Society, and soon afterwards became a volunteer working in the Entomology Section of Liverpool Museum, National Museums and Galleries on Merseyside, on a biodiversity study of the invertebrate fauna of the Greek island of Chios.

It was recognised that the development of a high quality technique for photographing insect specimens would significantly enhance the availability of museum information for taxonomic and identification purposes. Detailed images of interesting specimens could be easily sent to any number of overseas specialists without risking damage to delicate specimens. Transfer of high quality images onto Photo CD format, and availability over the Internet, would also be natural and desirable developments. In order to produce a Photo CD of high quality photographs of set specimens, it would be necessary to develop a photographic technique which had the following features:

The method of illuminating the specimens would have to be standardised and consistent, including controlled directionality. Ring flash would have to be discounted, due to its limitations when photographing metallic or iridescent colours and surface sculpturing. The colour temperature limits of the lighting would have to be agreed. The need for consistent colour standards would require the nomination of a specific colour reversal film. Film format would be 35 mm. A standard background colour, or a small number of standard options, would need to be agreed. In addition to these essential features, it was considered desirable to make the equipment transportable, robust but not too heavy, inexpensive to construct and easily made. Equipment would need to be readily adaptable to current 35 mm cameras and systems.

Progress to date

Initial photographic experiments in 1996 soon showed that there were severe limitations regarding the use of fibre-optic illumination and photomicrography, mainly with respect to contrast control and convenience of use when presented with specimens covering large size differences. Consequently development priority was given to the achievement of even illumination with controlled directional bias and correct contrast. Using natural north light as the experimental light source, an articulated mirror system was developed which achieved all these requirements.

The results from the equipment shown in Figure 1 were encouraging, yielding good overall contrast and directionally controlled illumination by way of a cheap, easily produced and adaptable basic mirror design. However there were limitations due to the need for good daylight and weather. In addition, small apertures and long extension tubes resulted in very long exposures (up to two minutes), often resulting in reciprocity failure in the film emulsion. The equipment was very large and heavy and was not really portable.

To cater for very small specimens of insects with body lengths down to 2 mm or small structural details down to 0.3 mm, which resulted in short objective-lens-to-object distances, it was recognised that the use of bellows-mounted photographic lenses would be precluded due to interference with the articulated mirror system. All development was therefore based upon the use of extension tubes.

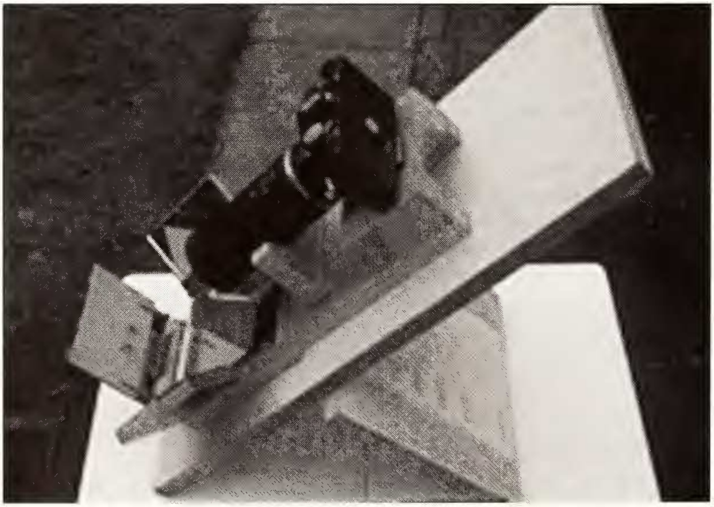


Figure 1. Articulated Mirror Development.

The next development phase was therefore devoted to adapting the system to the use of artificial light. Early experiments into the use of fixed Photoflood light sources soon showed up a number of shortcomings, mainly excessive heating-up of equipment and specimens, and also impractical aspects associated with specimen management and staging and image adjustment and focusing. All subsequent development was based on the use of electronic flash light sources, initially directly onto the articulated mirror system, with unsatisfactory results. Equipment and techniques were then developed which replaced the natural 'North Light Open Sky' source with an artificial one based upon a highly reflective light-scattering top panel which was illuminated using electronic flash.

Several problems had to be overcome before full development could be completed; these included optimising the positioning of the electronic flash units in relation to top and side reflecting panels, the articulated mirror system, the specimen stage, extension tubes and the camera objective lens. In completing this work, the equipment and techniques associated with its use had to avoid the need to use powerful flash guns, in order to reduce cost, size, weight and to ensure portability. Interference with specimen management regarding positioning, orientation, changing specimens, focusing and flare in the resulting photographs had also to be avoided.

Development of equipment and the techniques for using it were completed in the late summer of 1998.The camera equipment used in the prototype system comprised Olympus OM2n, OM2SP, and OM4 cameras; extension tubes; Olympus 50 mm Macro, 38 mm Macro and 20 mm Macro lenses. Experiments were also made using a reversed 24 mm Olympus wide-angle lens. The flash guns used were one Olympus T32 and one T20. An additional Sunpak 3500 flash gun was used for photographing at very high magnifications with the 20 mm Macro lens. Exposures were automatic using the camera systems together with standard Olympus connectors. Current work is standardised on Fujichrome Velvia slide film ISO 50/18°, and Agfacolor Ultra 50 Professional for prints. The new Fuji Provia 100F slide film is currently being assessed, including rating this film at up to 400 ASA. All specimens are staged against a standard background comprised of photographic 'grey card'.

Description of the developed equipment

Figure 2, with top panel and flash guns removed for clarity, shows the relationship between the five modules which, when assembled together, create the operating system.

The function of the baseboard is to hold together the Light Diffuser in its correct relationship to the camera platform, the flash gun/stage carriage and the Articulated Mirror Assembly. The base board is made from white-painted 3 mm thick hardboard; in the prototype this was 610 mm wide and 510 mm deep. The lateral constraint for the other modules is provided by two pieces of wood, 19 mm by 11 mm and 380 mm long, screwed and glued to the hardboard.

Figure 3 shows the underside view of the camera platform. The prototype platform is made from a piece of seasoned oak 20 mm thick by 388 mm long and 148 mm wide. Two additional pieces of oak, together totalling 43 mm in thickness, 148 mm wide and 94 mm long, are pinned and glued to one end to form the raised camera mounting position. As shown in the inverted view, the rear of the platform is hollowed out underneath to allow for easy access to the locking collar when changing cameras. The actual camera seating and locking collar used on the prototype was salvaged from a broken pan-and-tilt head. The height of the additional pieces of wood at the camera end of the platform suits the use of Olympus cameras; some

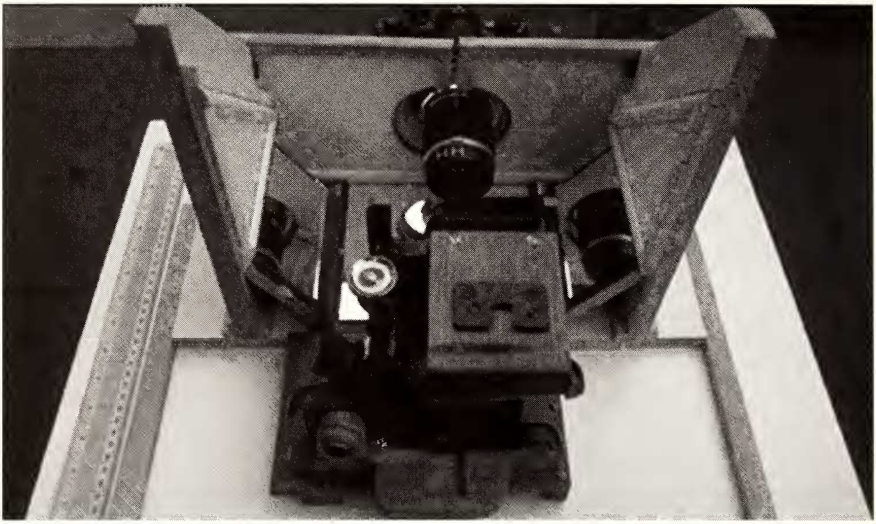


Figure 2. The developed equipment.

alteration may be required to this dimension if other makes of camera are used. The overall length of the platform can be increased or reduced depending upon the size of camera being used and the maximum length of extension tubes plus lens envisaged. In the case of Olympus cameras, with a reversed 24 mm lens and an extension tube length of 205 mm, the overall length of the camera platform would need to be 600 mm.

Figure 3. Camera platform underside.

The design can be modified to cater for the use of platform extension pieces so as to make the equipment more compact for transport purposes. An additional saddle support is used with long extension tube lengths to ensure rigidity in operation.

Figure 4 shows the two articulated mirror assemblies required to operate the system over the range of lenses and extension tube lengths described. The longer one is used for cases requiring longer focal length lenses and longer extension tubes. The method of construction is the same in both cases, the only differences being in overall length.

The construction of the mirror assemblies is based on a simple wooden saddle. In the prototypes these were made from 12 mm thick high-quality plywood, 177 mm wide by 178 mm long (107 mm for the shorter mirror). Lateral constraint was provided by longitudinal wooden side pieces made from oak and separated by a distance slightly greater than the width of the main length of the Camera Platform, so as to allow for ease of sliding them along; the thickness of the side pieces was slightly less than the thickness of the camera platform for the same reason. The base mirror covers most of the upper surface of the saddle. The wing mirrors, fastened by brass hinges to the sides of the mirror saddle, are shorter in length than the base mirror by a length of 45 mm and positioned at the end furthest from the camera. This is to cater for the overlapping of the rear light diffuser panels over the rear edge of the base mirror when assembled. The width of the wing mirrors is the maximum which will allow the mirrors to be stowed away with the side mirrors folded mirror-to-mirror with the base mirror. In the prototype mirrors, this resulted in side mirror assemblies 85 mm wide, including space for the brass hinge. Mirror glass used is 4 mm thick and fastened to wood using flexible mirror glass adhesive. The prototype larger mirror was provided with a clamping screw fitted to one of the side members, but this feature did not prove to be necessary in practice.

Figure 5 shows five reflecting panels which make the light diffuser: Two side support panels are used to support the top reflecting panel at an angle of 45° to the

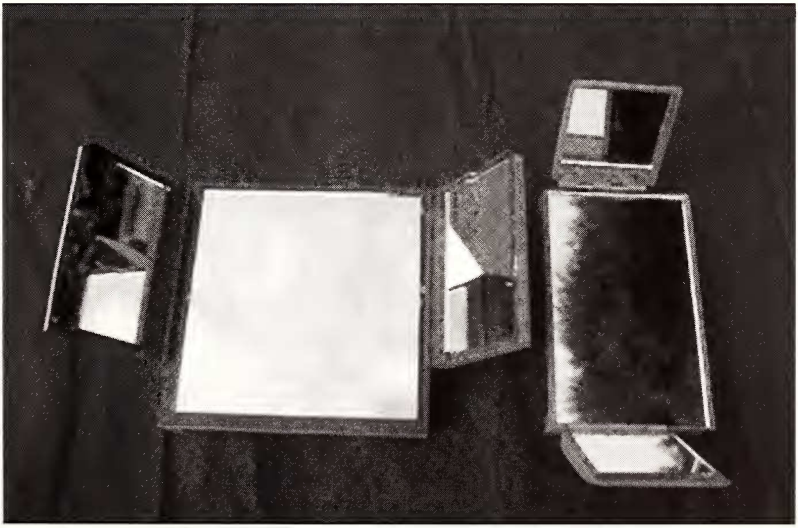


Figure 4. Articulated Mirror Assemblies.

horizontal and to fix the wing mirrors at angles of 45° to the horizontal when deployed to the maximum extent. The other two reflecting panels are the two rear ones which surround the extension tube/lens combination during operation.

The top reflecting panel measures 298 mm across by 199 mm wide overall, the edge members being 20 mm thick. The reflecting surface, in common with all diffuser reflecting surfaces, is made by fixing a piece of 4 mm mirror glass to the base using mirror glass adhesive. Positioned on top of this is a piece of 2 mm thick translucent, opaque, white, textured plastic as the actual light scattering and diffusing medium (Polystyrene 'Cracked Ice Opal' from Glaziette Ltd., Manchester, telephone 0120 479 1185), and it is secured in position by the wooden edge members. This piece of plastic is placed with the textured surface facing the light source and the smooth surface against the mirror.

The prototype side support panels were made from 17 mm white-faced chipboard, with base dimensions 130 mm wide by 138 mm long; the vertical side pieces are 148 mm long and 170 mm high at the rear, but 290 mm high at the front. When assembled onto the base, the overall height of the upper surface of the top panel bearers on the side pieces is 287 mm high at the front and 143 mm high at the back. The height of the base of the bottom triangular diffuser panel support above the top of the side panel base is 89 mm. A metal stop is screwed to the rear top edge of each side member to stop the top reflecting panel from sliding down the panel bearers during operation. Cut-outs are made in the base members to clear the articulated mirror clamping knob, if fitted, and the corners of the flash gun/stage carriage if necessary. The triangular side diffuser panels are made in the same way as described for the top panel.

The two rear reflecting panels are also made from 17 mm white-faced chipboard and are designed to reflect light back onto the subject directly and by re-reflection. When pushed together, these two panels create a reflecting surface 340 mm wide overall, including edge members 150 mm high, except for the central circular clearance for the lens/extension tube assembly. When in position, the inboard lower

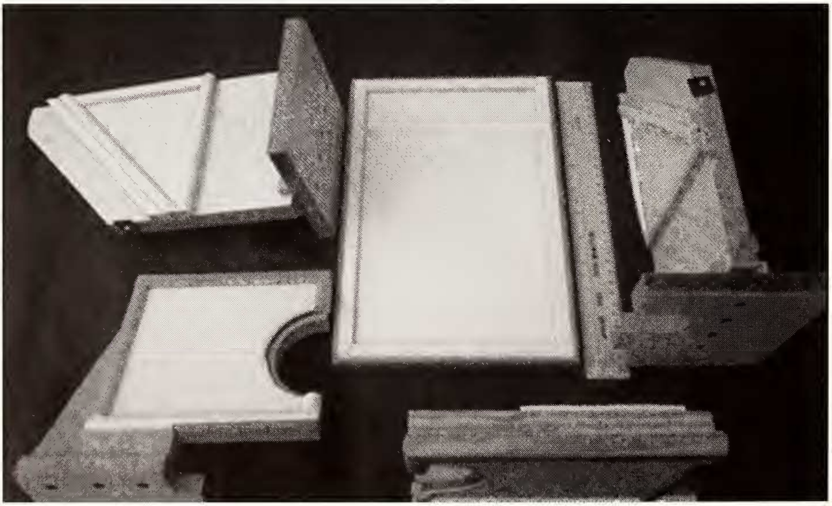


Figure 5. Components of the Light Diffuser.

surfaces of the rear reflecting panels rest on the surface of the base mirror of the articulated mirror assembly at the edge nearest to the camera, a height of 38 mm above the base board on the prototype system. Provision was made for this by shortening the lengths of the wing mirrors by 45 mm as noted before. The bases of the rear reflecting panels, 72 mm long by 123 mm wide, are cut out at their inboard forward corners to clear the corners of the articulated mirror assembly saddle. When assembled, the height of the tops of the rear reflecting panels is 189 mm above the base board.

For basic photography of specimens, where there is no requirement to use special highlighting of features by means of additional fibre-optic illumination, lightweight versions of the top and rear reflecting panels have been developed. Construction is based on artists' mounting board upon which is placed a piece of thin mirrored plastic film. The insides of potato crisp packets and silver-mirror-finished party balloon material were used with equal success. A piece of 'Cracked Ice Opal' is finally placed on top and the whole assembly secured by placing pieces of plastic document binders of triangular section along the edges.

Figure 6 shows the flash gun/stage carriage, with the flash guns removed for clarity; its function is to provide a stable base for the specimen stage and a method of moving the specimen longitudinally in order to achieve precise focusing without backlash. It must also provide a means of lateral and vertical adjustment of the position of the specimen to give the required orientation to the camera. The carriage must provide correct positioning of the flash guns so as to maximise the use of light and eliminate the risk of flare.

The design and construction of this module is based upon a saddle platform which can be moved along the camera platform to suit the positioning requirements dictated by the selected combination of extension tube length and lens. In developing the prototype system this module was based upon the use of a dissecting stand and associated mechanism. A heavy black-lacquered brass dissecting stand by Prior of

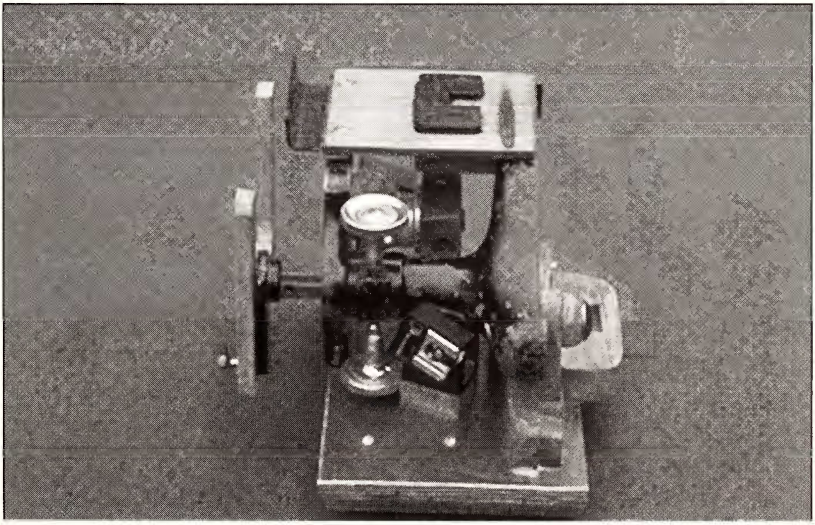


Figure 6. Flash Gun/Stage Carriage.

London, which included a triangular cross-section rack-and-pinion stage-positioning mechanism, was purchased for £5 in a used equipment sale at a meeting of the Manchester Microscopical Society.

This stand was carefully fastened on its side to the saddle platform to give a smooth horizontal traverse of the rack along the axis of the camera platform. All superfluous items were removed including an articulated magnifying glass and a concave adjustable reflecting mirror. The stand was positioned so that one of the knurled brass pinion adjustment wheels was uppermost for ease of operation when fine focusing the specimen using the camera viewfinder.

The specimen holder was made from Tufnol, a fabric-reinforced resin material, 8 mm thick and 133 mm wide by 105 mm high, fitted with two microscope stage clips and attached to the end of the dissecting stand rack. The vertical positioning of the specimen holder was such that it rested gently on the base mirror surface of the articulated mirror assembly during operation. The dissecting stand rack-and-pinion provides fine horizontal adjustment over a distance of 62 mm, vertical and lateral adjustment of the specimen was achieved manually by sliding the insect staging grey card between the microscope stage clips and the Tufnol support.

The saddle platform for the prototype system was made from 12 mm thick high-quality plywood, 210 mm wide by 125 mm long, with lateral restraint provided by longitudinal oak side pieces screwed and glued to the underside of the platform, the separation between these side members being slightly larger than the width of the camera platform. The platform was extended slightly to one side to cater for the positioning of a side-mounted flash gun (Olympus T20). The upper side arm and side of the base of the dissecting stand provided convenient attachment points for a piece of 5 mm plywood, 84 mm wide by 104 mm long, upon which the accessory shoe for the Olympus T32 flash gun was mounted.

Provision was also made in the prototype system for the side mounting of a second Olympus T20 flash gun via a shoe placed on an adjustable mount on the saddle base between the lower arm and base side of the dissecting stand.

Experimentation demonstrated how critical the positioning of the flash guns was in relation to the top reflecting panel. The upper flash gun, the T32, had to be as close as possible to this panel and had to be horizontal; likewise the side-positioned T20 flash guns had to be as close to the top corners of the insect staging board as possible. The insect staging boards have now been standardised on photographic grey card, 150 mm wide by 105 mm high.

Figure 7 shows how the specimen staging boards are positioned in relation to the flash guns so that the lens is screened from direct light from them, thus avoiding flare.

For photographing very small specimens at high magnifications, e.g. when using the 20 mm Macro lens with a very small working distance (17 mm), it was necessary to develop a special flash gun and stage carriage incorporating a microscope mechanical stage for precise specimen position adjustment.

Figure 8 shows the carriage fitted with a CT-11 mechanical stage purchased from Lakeland Microscopes for £34. Provision has also been included for the necessary additional Sunpak 3500 flash gun.

Figure 9 shows how to construct a reversal arrangement when special Macro lenses down to 20 mm in focal length are not available. A reversal arrangement was constructed for the prototype system using a Tamron Adaptall 2 Olympus mount attached using a plywood annulus and epoxy resin to a threaded coupling ring to suit the filter thread at the front of an Olympus 24 mm lens. In order to be able to stop this lens down to f/16 an adaptation was made to an Olympus lens base cap whereby a curved plywood piece was fixed inside, using epoxy resin, to operate the lens stop

Figure 7. Relative positions of specimen staging boards and flash guns.

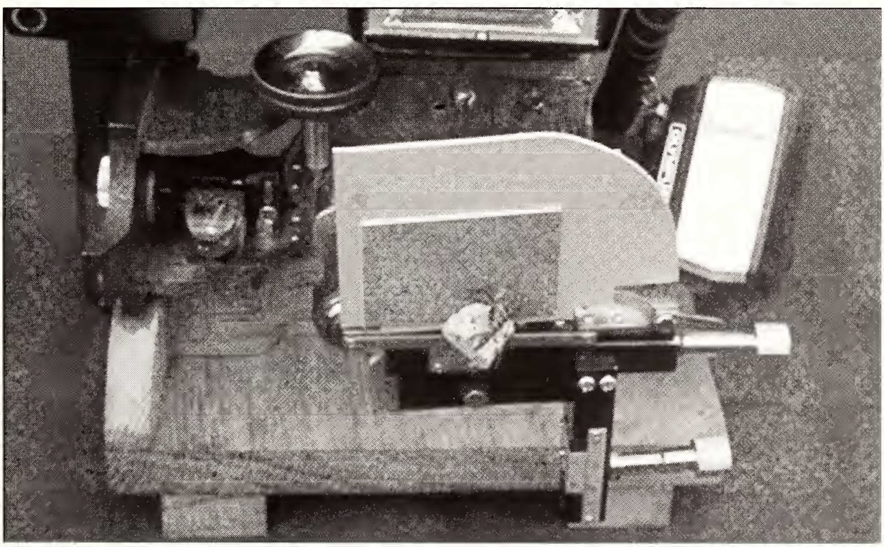


Figure 8. Stage Carriage fitted with mechanical stage.

down lever by rotating the cap. The centre of the cap was cut away to give a 30 mm diameter hole. This also acted as a lens hood.

Figures 10 and 11 show the complete system assembled and ready for operation.

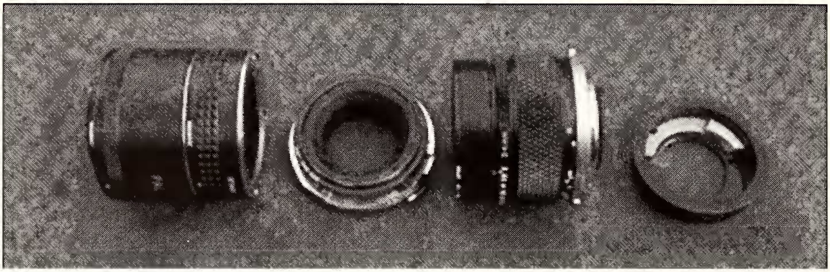
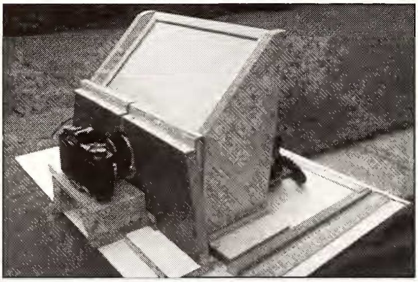
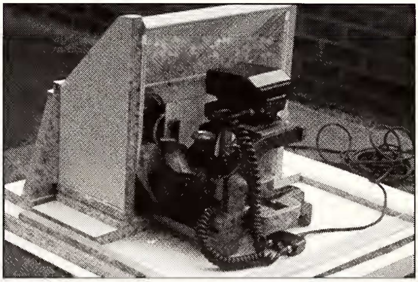


Figure 9. Lens reversal arrangement.





Figures 10 and 11. Complete system.

Figure 12. System in operation.

Operation of the developed equipment

Figure 12 shows the prototype system in use. A spotlight is mounted on the wall; this is directed at the upper diffuser panel to provide sufficient light for specimen position adjustment, orientation and fine focusing. Two mirrors strategically placed behind the flash guns, and can be used to confirm that both guns are fully charged and ready to fire before releasing the camera shutter, as shown by the 'ready lights' on the backs of the flash guns. The camera viewfinder indicator cannot be used for this because it will indicate ready-to-fire with only one of the flash guns fully charged. The wall-mounted spot light is switched off prior to releasing the camera shutter.

Fine focusing is usually carried out with the top diffuser panel removed and the camera objective lens wide open. When using high magnifications, additional fibre-optic illumination is used to illuminate the specimen during focusing; it is then removed prior to shutter release. When correct focus has been achieved, the lens is then stopped down when manual or reversed lenses are being used, and the top Diffuser Panel replaced before releasing the shutter.

Several photographic grey card insect stages were made to enable insects prepared in different ways to be photographed; this enables side-pinned, top-pinned, carded and pointed insects to be photographed in different orientations, either completely or partially, normally or inverted. Most whole insects are photographed using the 50 mm and 38 mm Olympus Macro lenses and modest length extension tubes.

When using Fuji Velvia 50 ASA film, correctly exposed photographs are obtained with both the 50 mm and 38 mm Macro lenses stopped down to their minimum apertures, f/22 and f/16 respectively, over a range of extension tube lengths up to 100 mm. With the 20 mm Macro lens, the minimum aperture of f/16 is usable with extension tube lengths up to approximately 40 mm, f/11 up to approximately 90 mm, reducing to only f/4 at an extension tube length of 200 mm.

For maximum magnification, short focal length lenses in combination with long extension tube lengths are required. The maximum magnification obtained to date has been achieved using a 20 mm Olympus Macro lens and 200 mm extension tube. This gave an image 20 times life size on the slide, the lens being stopped down to f/8 when using Fuji Provia 100F film. However the resulting small depth of field in these circumstances makes satisfactory photography of highly curved small insects or parts of insects difficult to achieve. Currently experiments are in hand with the use of Fuji Provia 100F film rated at 400ASA and 'push' processed by two stops, thus allowing the use of the lens fully stopped down to f/16 for maximum depth of field.

With the Olympus system, correct exposure is indicated by a flickering of the 'flash ready' light immediately on releasing the shutter. Trials indicate that in practice correctly exposed slides are always achieved with the lens stopped down by one stop further than that required to indicate correct exposure in the viewfinder. It is suspected that the Olympus system triggers the flickering of the 'flash ready' light when the camera's automatic exposure system attenuates the flash duration to achieve correct exposure. Thus when the flash guns only just provide sufficient light to correctly expose the film, attenuation is not imposed by the camera system and the 'flash ready' light does not flicker.

From time to time it is necessary to apply more intense illumination to small parts or areas of specimens, in order to show details of structure, colour and pollination. This is usually associated with the use of high magnifications. Figure 13 shows the set-up used for photographing the diagnostic glossy propodeum of the female mason bee *Osmia xanthomelana* Kirby. The rear right-hand reflecting panel was removed to allow access for the fibre-optic directed lighting, the specimen was inclined nose-down on the photographic grey staging card and the fibre-optic light directed at the correct angle to achieve the desired presentation. In this case the Olympus 38 mm Macro lens was used together with a 100 mm Extension Tube at f/11 on Fuji Provia 100F film. The camera shutter speed was set manually at 1 second to produce the best highlight exposure; it is not possible to use the camera's automatic exposure

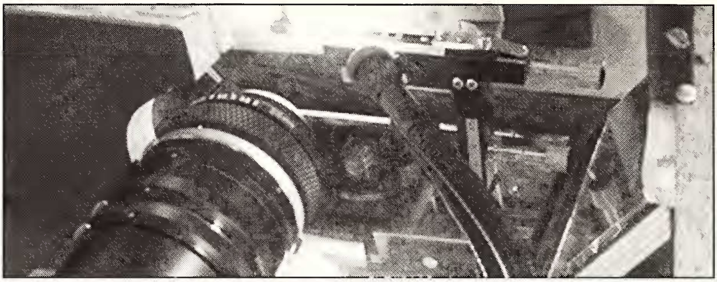


Figure 13. Special illumination with additional fibre-optic directed lighting.

system in these circumstances. Stability of the light diffuser precludes the use of the lightweight rear reflecting panels, described earlier, in these applications.

Photographs of a mixed batch of 36 insects of various sizes from 2 mm to 100 mm in body length, which require changes in extension tube lengths and lenses, can typically be taken in less than two hours. Extension tube lengths and lens combinations are selected to fill 80% of the picture area.

Digital photography

A paper on the development of equipment for the digital photography of set specimens, completed at Liverpool Museum this year, using a Nikon 995 camera will be published in a future part of the journal.